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2009 Exploring Giant Planets on NIF: A New Generation of Condensed Matter Workshop

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2009 Exploring Giant Planets on NIF: A New Generation of Condensed Matter Workshop
Livermore, CA, United States
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Disclaimer

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Jon Eggert

DACs in the '80s ⟺ Laser Compression in the 00's

DACs	Lasers
Ruby Calibration (Pressure, Temperature)	Quartz Calibration (Pressure, Temperature, Reflectivity)
Raman and Visible Spectroscopy	VISAR
X-ray Diffraction (energy dispersive)	X-ray Diffraction (angle dispersive)

The last 20 years have seen fantastic advances in DAC techniques, measurements, and diagnostics.

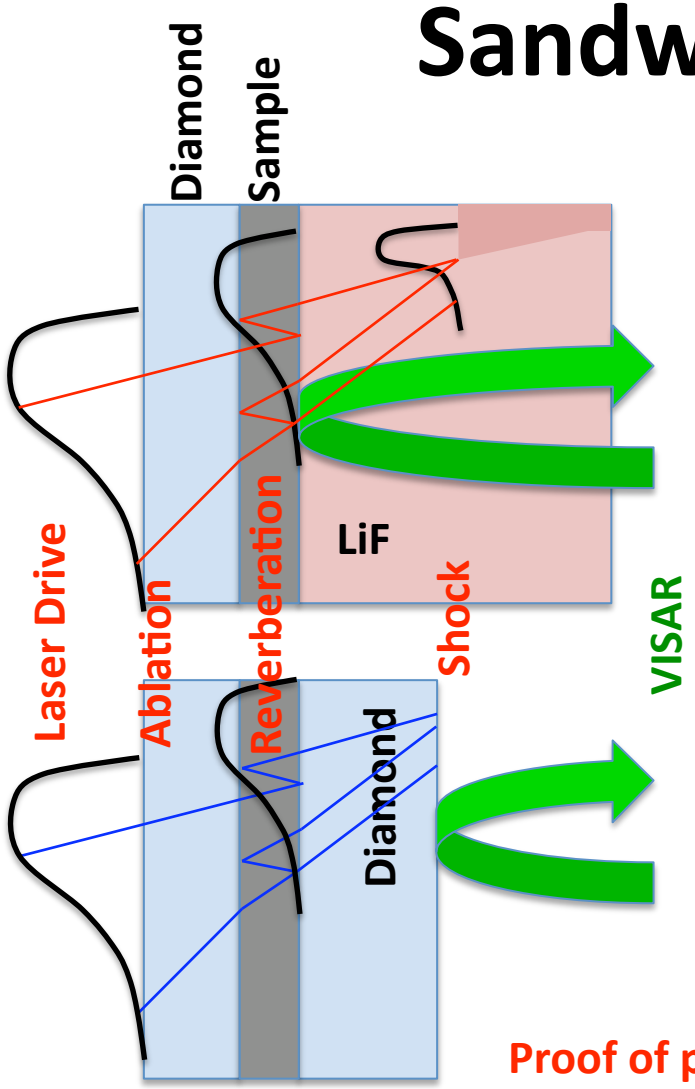
Our biggest challenge is to make similar progress in the next 20 years on laser-compression experiments.

We have demonstrated XAFS, Raman scattering, and white-light reflectance, but most measurements are still based on velocity wave-profile measurements.

The most important experimental advance will be the ability to produce a uniform sample state and perform in-situ measurments.

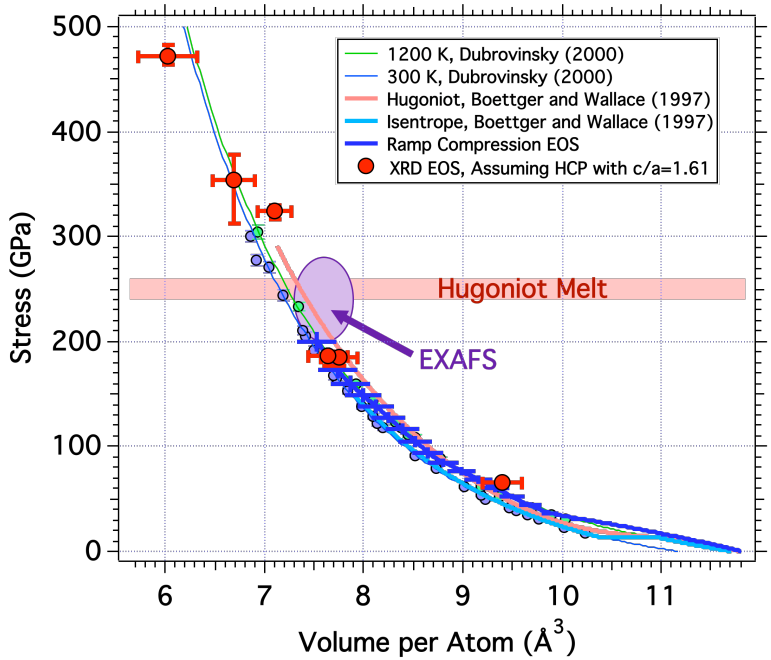
Unfortunately, transparent windows are rare (although LiF is transparent to at least 900 GPa under ramp compression) so x-ray diagnostics are crucial.

Sandwich Ramp-Compression



As long as the sample is hydrodynamically thin, *P* and *u* at the LiF or Diamond interface is the same as in sample

If we know the EOS of LiF or Diamond we can find the Pressure in the sample using the VISAR diagnostic



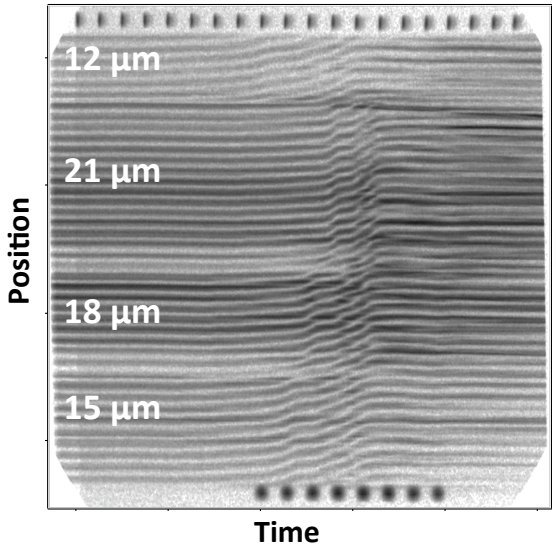
Proof of principle already demonstrated for XRD and XAFS on iron

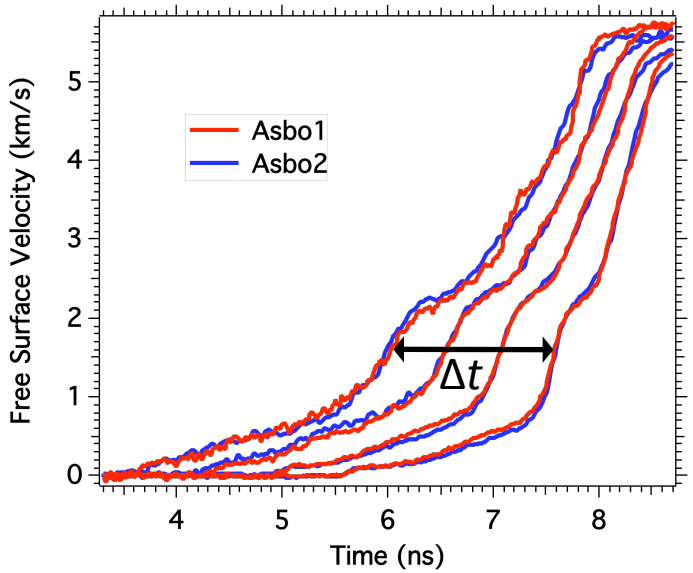
Using this target design, we believe we can ramp compress samples to ~30 GPa, Hold the state for several ns, Determine the pressure, and Make a measurement.

XRD, XAFS, XANES, Reflectivity, ... *Temperature remains the most important parameter that we do not know how to measure.*

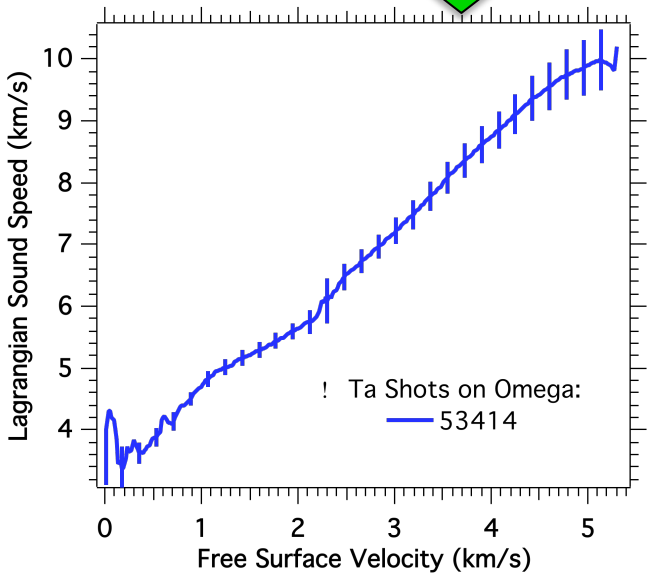
Backup Slides

We collect the data using a line visar and analyze it using iterative Lagrangian Analysis





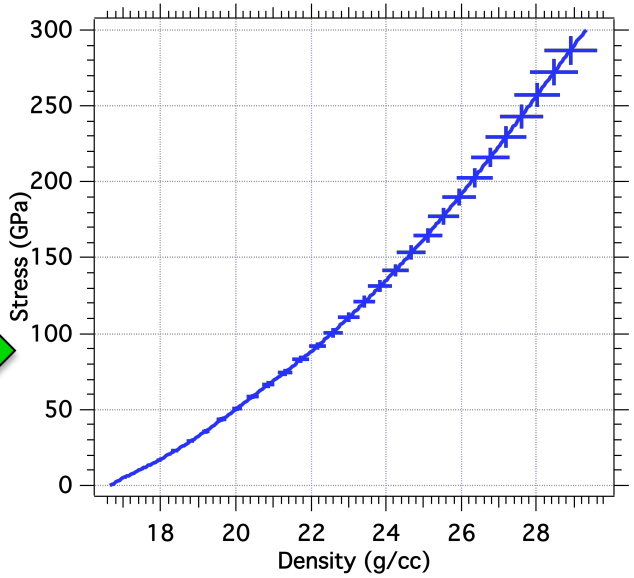
$$C_L(u) = \frac{\Delta x}{\Delta t}$$



Since we measure free surface velocity, not *u* we must use an iterative correction developed by Rothman (2005)

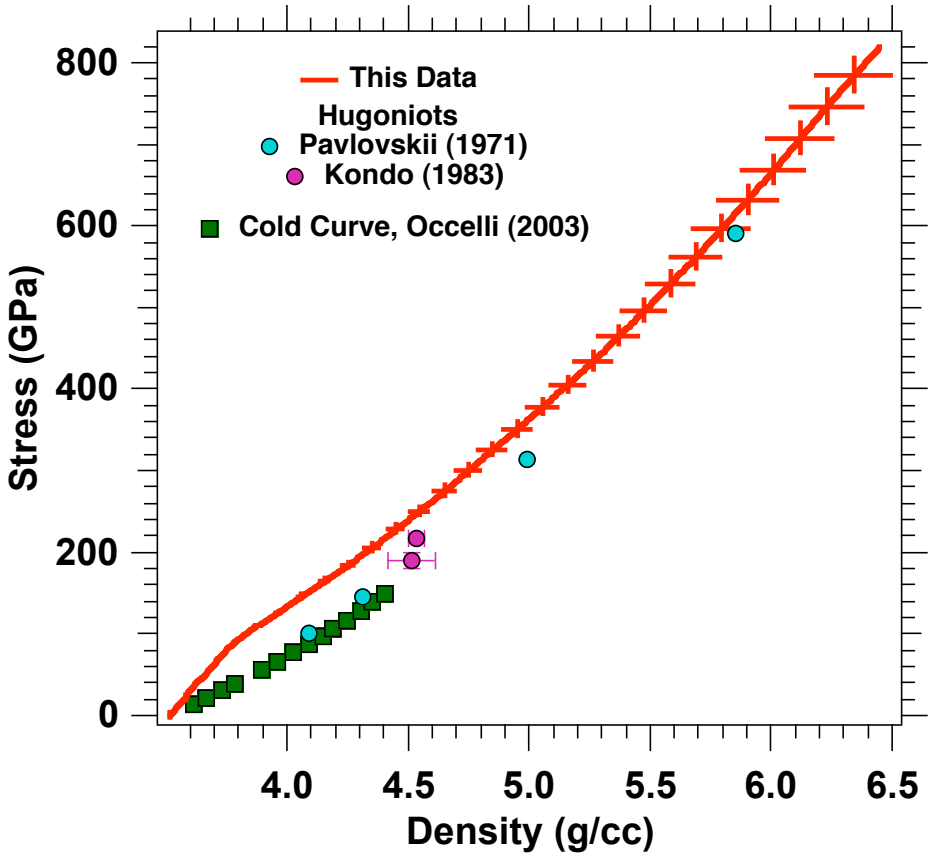
$$\rho(u) = \rho_0 \left(1 - \int du/C_L\right)^{-1}$$

$$P_x(u) = \rho_0 \int C_L \, du$$

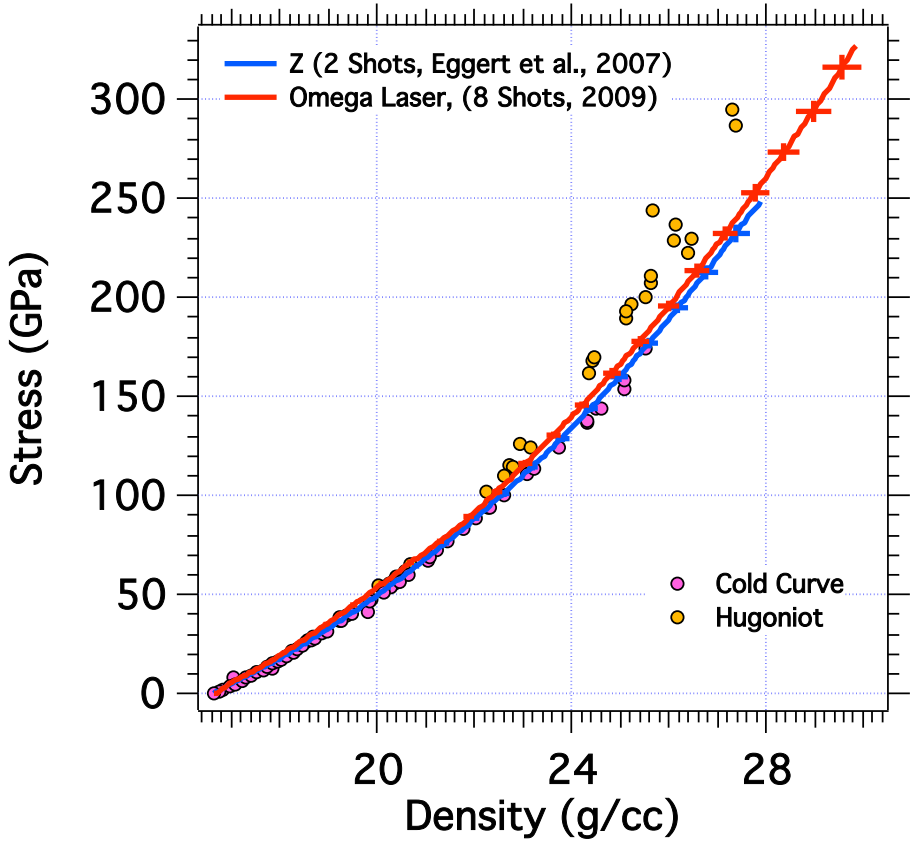


EOS Measurements

Diamond

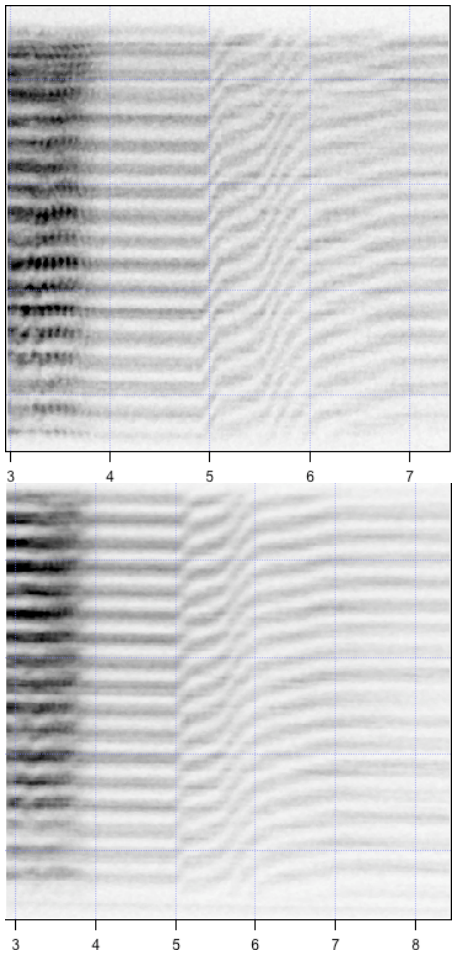


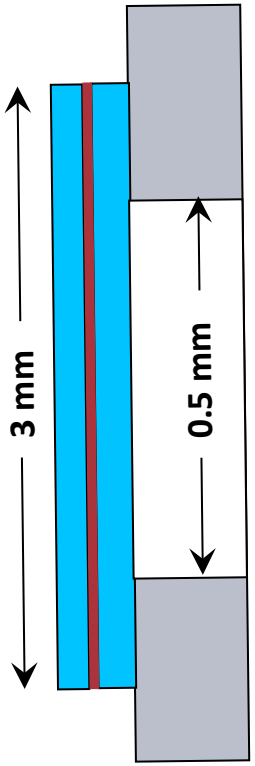
Tantalum

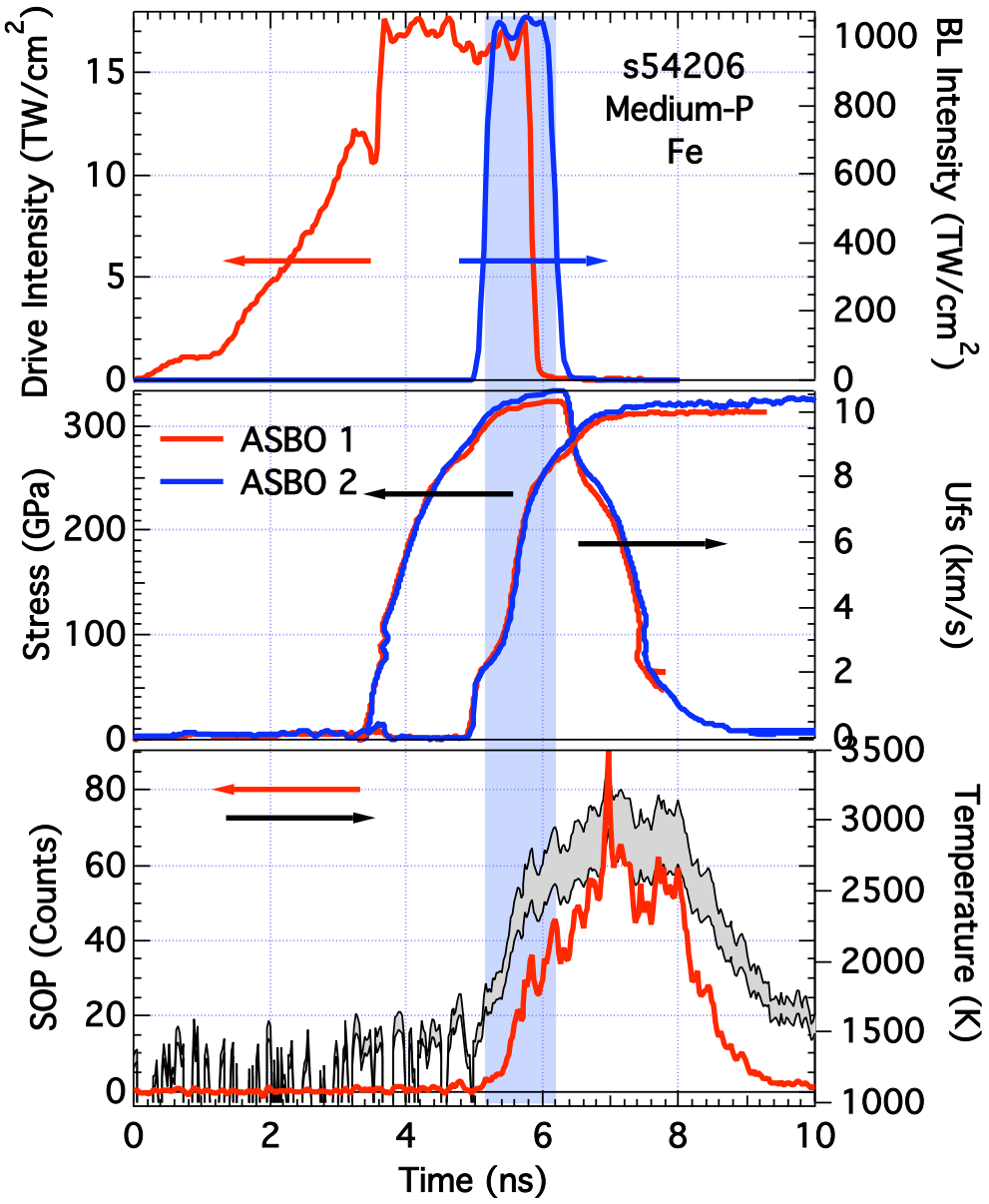


We still need to perform measurements on LiF.

s54206, Fe X-ray Diffraction



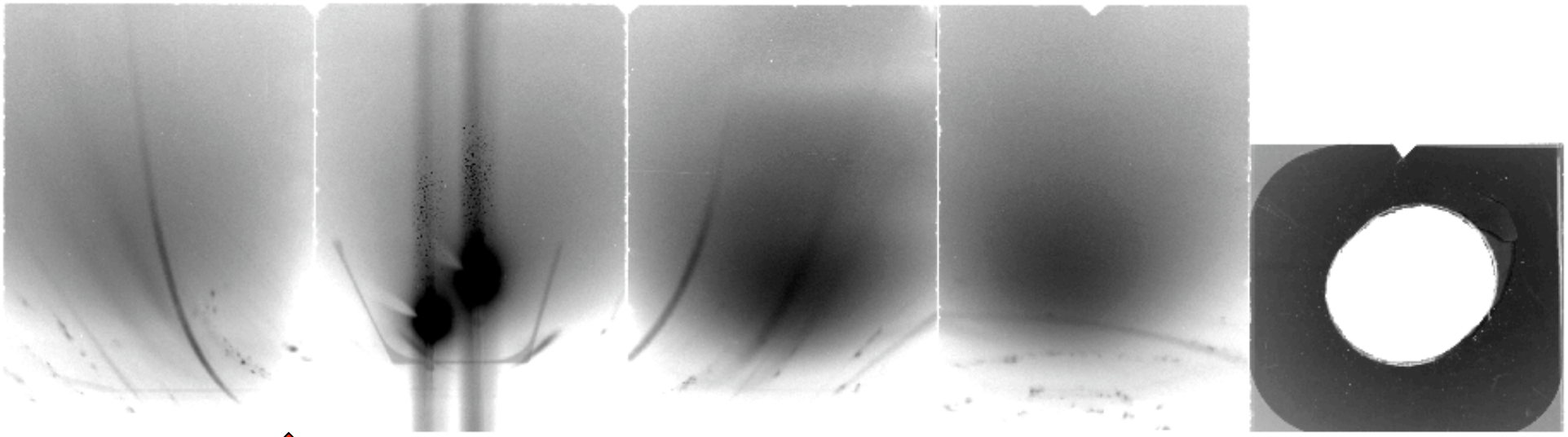




Strain rate is very high, ~10^8 s^{-1}.
Looks like temperature is low.
What does diffraction look like?

Shot 54206, Fe X-ray Diffraction

$$P = 324^{+9}_{-15}\ \text{GPa}$$



Raw Data

Wavelet-FT Background Subtraction